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MOJAVE WATER AGENCY

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Stamos, C.L. and Predmore S.K., 1995, Data and Water-Table map of the Mojave River Ground-Water basin, San Bernardino County, California, November 1992

Data and Water-Table map of the Mojave River Ground-Water Basin, San Bernardino County, California, November 1992

By Christina L. Stamos and Steven K. Predmore, 1995

Introduction

The Mojave River Basin is located about 80 mi northeast of Los Angeles, California. The proximity of the Mojave River Basin to the highly urbanized Los Angeles region has led to a rapid growth in population and, consequently, an increase in the demand for water. The Mojave River, which is the primary source of surface water to the region, normally is dry--with the exception of a few reaches of perennial flow, and periods of flow following intense storms. The intermittent availability of surface water has forced the region to rely almost entirely on ground water to meet its agricultural and municipal needs. To plan for anticipated future water demands, there is a need to understand present ground-water conditions.

The U.S. Geological Survey, in cooperation with the Mojave Water Agency, constructed a water-table map of the Mojave River ground-water basin for the purpose of describing the present (November 1992) ground-water conditions. Water-level data were collected from approximately 300 wells to construct the map, which shows the altitude of the water table and general direction of ground-water movement. One of the objectives of the study was to determine if subsurface flow is entering the Alto subbasin from the Oeste and Este subbasins of the Mojave Water Agency management area (fig. 1). The results of this study will be used to aid ongoing studies by the U.S. Geological Survey, such as the Southern California Basins Regional Aquifer-System Analysis (RASA).

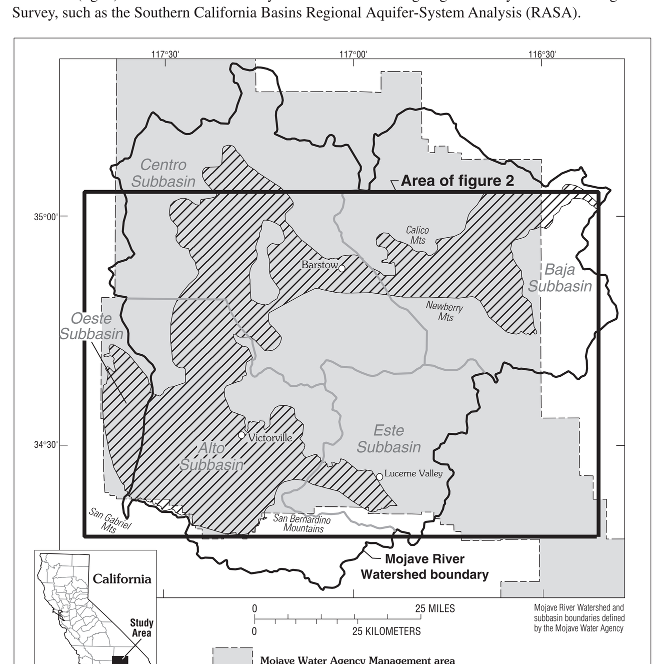


Figure 1. Location of Mojave Water Agency management area and subbasins.

Description of Study Area

The Mojave River Basin is part of the Mojave Desert region of southern California and covers approximately 2,100 mi^2. It is bounded by the San Bernardino and San Gabriel Mountains to the south and extends to Afton Canyon to the northeast. It is bounded on the east by the Lucerne Valley and on the west by the Antelope Valley. The Mojave River, the principal source of recharge to the basin, originates in the San Bernardino Mountains, and when surface water is present, it flows northward through Victorville, then eastward through Barstow, and leaves the ground-water basin at Afton Canyon almost 100 mi from its headwaters.

The climate of the basin is typical of arid regions of southern California; it is characterized by low precipitation, low humidity, and high summer temperatures. Mean annual precipitation in most of the basin is less than 6 in., although it is greater than 20 in. in the San Bernardino Mountains to the south. Although this desert region is mostly undeveloped, it is host to numerous communities that are expanding rapidly, and several military bases. Agriculture is concentrated primarily along the Mojave River, near Harper (dry) Lake, and near the community of Newberry Springs.

Geohydrology

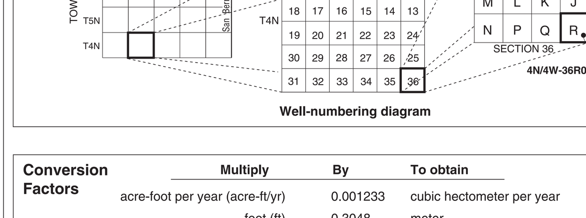
The ground-water basin boundary, as defined in this study, was modified from Hardt (1971) and coincides, in most places, with the contact between the unconsolidated deposits and the non-water-bearing consolidated rocks. The consolidated rocks are composed of igneous and metamorphic rocks and underlie and form the mountains and hills that surround the 1,400-square-mile ground-water basin. In some places within the basin and along the boundary, the consolidated rocks are not exposed at the surface, but they are present above the altitude of the water table.

The water-bearing deposits are unconsolidated and partly consolidated continental deposits that form two aquifers, a shallow alluvial aquifer and an underlying regional aquifer. The shallow alluvial aquifer overlies the regional aquifer along the Mojave River and is the more productive aquifer, yielding much of the ground water that is pumped from the basin. The alluvial aquifer is composed of very permeable younger river deposits of Holocene age and older river deposits of Pleistocene age that are about 200 ft thick and lie within about 1 mi of the Mojave River. The regional aquifer extends throughout most of the study area and is composed of unconsolidated older alluvium and fan deposits of Pleistocene to Tertiary age, and partly consolidated to consolidated sedimentary deposits of Tertiary age. These deposits are as much as 1,000 ft thick in some places and their permeability generally decreases with depth.

Structurally, the Mojave River ground-water basin is dominated by extensive right-lateral strike-slip faults, which trend predominantly northwest to southeast and which displace the regional aquifer and, in many places, the shallow alluvial aquifer. These faults cause abrupt, stairstep-like drops in the water table at the fault zones; between the fault zones, the water table is relatively flat (fig. 2). It has been documented in previous studies (California Department of Water Resources, 1967, p. 28; Hardt, 1971, p. 21) that these structures are barriers, or partial barriers, to ground-water flow. Historically, areas where ground water was forced to the surface by these barriers were used as desert watering places for many years (Thompson, 1929).

Well-Numbering System

Wells are identified and numbered according to their location in the rectangular system for the subdivision of public lands. Identification consists of the township number, north or south; the range number, east or west; and the section number. Each section is divided into sixteen 40-acre tracts lettered consecutively (except I and 0), beginning with A in the northeast corner of the section and progressing in a sinusoidal manner to R in the southeast corner. Within the 40-acre tract, wells are sequentially numbered in the order they are inventoried. The final letter refers to the base line and meridian. In California, there are three base lines and meridians; Humboldt (H), Mount Diablo (M), and San Bernardino (S). All wells in the study are are referenced to the San Bernardino base line and meridian (S). Well numbers consist of 15 characters and follow the format 004N004W36R001S. In this report, well numbers are abbreviated and written 4N/4W-36R01. Wells in the same township and range are referred to in figure 2 by only their section designation, 36R1. The following diagram shows how the number for well 4N/4W-36R01 is derived.



Well-numbering diagram

Conversion Factors Multiply	By	To obtain
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year
foot (ft)	0.3048	meter
foot per year (ft/yr)	0.3048	meter per year
gallon per day (gal/d)	0.003785	cubic meter per day
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Water-table Map

The water-table map was constructed using U.S. Geological Survey water-level measurements from approximately 300 wells and additional water-level measurements reported by local water agencies. All water-level measurements made or compiled for this study are given in table 1.

The water table is defined as the surface at which the fluid pressure in the pores of a porous medium is exactly atmospheric. The location of this surface is revealed by the level at which water stands in a shallow well open along its length and penetrating the surficial deposits just deeply enough to encounter standing water at the bottom (Freeze and Cherry, 1979, p. 39).

Multiple-well monitoring sites installed as part of the RASA study indicate that at sites where both the shallow alluvial and regional aquifers are present, water levels vary with depth, but they generally are within about 10 ft of each other. Where data from both aquifers were available at the same location, such as at a multiple-well monitoring site, water levels from the shallowest wells were used to construct the water-table map. In areas where the alluvial aquifer was not present, water levels from the regional aquifer were used. Most of the data were collected in November 1992 because that period preceded the effects of winter stormflow in the Mojave River and was a time when ground-water pumping was at a minimum. Water levels in some areas of the regional aquifer were measured outside this time period in order to substantiate existing data, and to supply data where November 1992 measurements were lacking. These measurements (made during 1991-94) were considered appropriate for use in constructing the map because they are from areas of the regional aquifer where pumping is minimal and water levels are relatively static on a yearly basis.

Faults and other geologic structures control ground-water flow within the basin. Inspection of the map indicates that faults act as barriers to ground-water flow at several locations. Evidence of fault barriers is indicated by the abrupt change in the water-table altitude in the vicinity of the Harper Lake region, the Helendale Fault, the Camp Rock-Harper Lake Fault zone, formerly called the Waterman Fault (Cox and Wilshire, 1994), and the Calico-Newberry Fault. Other areas of steep water-level decline--such as north of Victorville and between the Helendale Fault and Iron Mountain--indicate the probable presence of subsurface faults or other geologic structures that control ground-water flow within the basin, but there is no surficial evidence to confirm their presence. In some places, consolidated rocks present at shallow depths obstruct ground-water flow and force water to the surface, such as at Upper Narrows, Lower Narrows, and Afton Canyon (California Department of Water Resources, 1967, p. 27). Although these conditions historically existed near Camp Cady (California Department of Water Resources, 1967, p. 27), pumping has lowered the altitude of the water-table in that area and, consequently, ground water no longer flows to the surface.

The southern part of the Helendale Fault near the town of Lucerne is a very effective barrier to subsurface flow. Inspection of the water-table map indicates that the direction of ground-water movement on the east side of the Helendale Fault is toward Lucerne (dry) Lake. Therefore, ground water east of the Helendale Fault in this area is considered to be outside the Mojave River ground-water basin as defined in this study. Ground-water flow patterns in the Lucerne Lake area have changed little since 1916-17, the time of the first available data (Schaefer, 1979, fig. 3). West of the Helendale Fault, ground water flows from the southwestern part of the Este subbasin toward the Alto subbasin (figs. 1, 2), and the water-table gradient is relatively flat. The amount of subsurface flow across the Alto/Este subbasins boundary can be estimated using the following form of Darcy's law:

$$Q = Tiw,$$

where Q is the quantity of subsurface flow [L^3],
T is the transmissivity [L^2/t],
i is the hydraulic gradient at the boundary [L/L], and
w is the width of the area through which the flow passes [L].

Hardt (1971, pl. 8) estimated that the transmissivity of the aquifer materials near the boundary of the Alto and Este subbasins ranged from 5,000 to 10,000 (gal/d)/ft. The width of the boundary is about 4 mi and the hydraulic gradient was determined from the water-table map to be 0.0025 ft/ft. On the basis of these estimates, the approximate subsurface flow from the Este subbasin to the Alto subbasin is 300 to 600 acre-ft/yr.

Available data in the southwestern part of the Mojave River ground-water basin are insufficient to estimate the quantity of flow near the Oeste/Alto subbasins boundary.

The water-table contours indicate that subsurface flow occurs across the northern part of the Helendale Fault from the Alto subbasin to the Centro subbasin along the Mojave River. Water-level data from multiple-well monitoring sites, as well as historical data, indicate that this fault restricts subsurface flow within the regional aquifer, but not within the overlying alluvial aquifer (Hardt 1971, p. 21). Ground water passing into the Centro subbasin flows either to the north, away from the Mojave River toward Harper (dry) Lake, or to the northeast through a narrow gap in the consolidated rocks on the south side of Iron Mountain. Steep water-level gradients between the Helendale Fault and Iron Mountain indicate the probable presence of subsurface faults or shallow geologic structures that impede subsurface flow to Harper Lake. On the east side of Iron Mountain, ground water flows away from the Mojave River toward the northwest to Harper Lake and also northeast toward the city of Barstow.

Ground water from the Centro subbasin crosses the Camp Rock-Harper Lake Fault zone and enters the Baja subbasin east of Barstow. Within the fault zone, the water-table gradient is marked by abrupt, stairstep-like changes in the water-table gradient, decreasing in altitude as water flows eastward. Water-level data from multiple-well monitoring sites indicate that the fault zone impedes ground-water movement in both the shallow alluvial aquifer and underlying regional aquifer. East of the Camp Rock-Harper Lake Fault zone, the water-table gradient is relatively flat as ground water flows northeastward through the Baja subbasin. However, as ground water enters the middle of the Baja subbasin, it is impeded by the Calico-Newberry Fault, as indicated by about a 50-foot drop in the water table on the east side of the fault. Water-level data from multiple-well monitoring sites on both sides of the Calico-Newberry Fault indicate that, as in the Camp Rock-Harper Lake Fault zone, ground-water flow is impeded in both aquifers.

Subsurface flow through the Baja subbasin is affected by low-permeability deposits present at shallow depths in two locations. Near Camp Cady, fine-grained unconsolidated deposits near the surface that are associated with ancient Manix Lake (California Department of Water Resources, 1967, p. 23) cause an abrupt change in the water-table gradient as ground water continues to flow toward Afton Canyon (California Department of Water Resources, 1967, p. 27). At Afton Canyon, low-permeability deposits present at shallow depths below the Mojave River restrict subsurface flow, forcing ground water to the surface before it exits the Mojave River ground-water basin.

Pumping also has affected the shape and gradient of the water table over time. The rapid development of the Upper Mojave River Basin--which includes the communities of Hesperia, Apple Valley, and Adelanto--and the subsequent demand for water have caused significant water-level declines. In comparison with 1964 water-level data reported by the California Department of Water Resources (1967, pl. 8), water levels have declined more than 50 ft in some parts of Apple Valley. A large cone of depression, caused by the removal of ground water from aquifer storage, has developed near the city of Adelanto, although suspected subsurface faults also may be affecting the water table. Additional data are needed to better understand the factors affecting ground-water flow in this region. Other areas of large water-level declines since 1964 include the region southwest of Harper Lake, where water levels have declined by about 60 ft, and the area southeast of the Calico-Newberry Fault in the Baja subbasin, where water level-declines range from 30 to 50 ft (California Department of Water Resources (1967, pl. 8).

Selected References

Bortugno, E. J., compiler, 1986, Map showing recency of faulting, San Bernardino Quadrangle: California Division of Mines and Geology regional geologic map series, San Bernardino Quadrangle-map no. 3A, scale 1:250,000.

California Department of Water Resources, 1964, Names and areal code numbers of hydrologic areas in the Southern District, 67 p.

-------- 1967, Mojave River ground-water basins investigation: California Department of Water-Resources Bulletin 84, 151 p.

Cox, B.F., and Wilshire, H.G.,1994, Geologic Map of the Yermo Annex and Vicinity, Marine Corps Logistics Base, Barstow, California: U.S. Geological Survey Open-File Report 94-681.

Freeze, A.R. and Cherry, J.A., 1979, Groundwater: Englewood Cliffs, New Jersey, Prentice-Hall, 604 p.

Hardt, W.F., 1971, Hydrologic analysis of Mojave River basin, California, using electric analog-model: U.S. Geological Survey Open-File Report, 84 p.

Schaefer, D. H., 1979, Ground-water conditions and potential for artificial recharge in Lucerne Valley, San Bernardino County, California: U.S. Geological Survey Water-Resources Investigations Report 78-118, 37 p.

Thompson, D. G., 1929, The Mohave Desert region, California, a geographic, geologic, and hydrologic reconnaissance: U.S. Geological Survey Water-Supply Paper 578, 759 p.

Vertical Datum

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

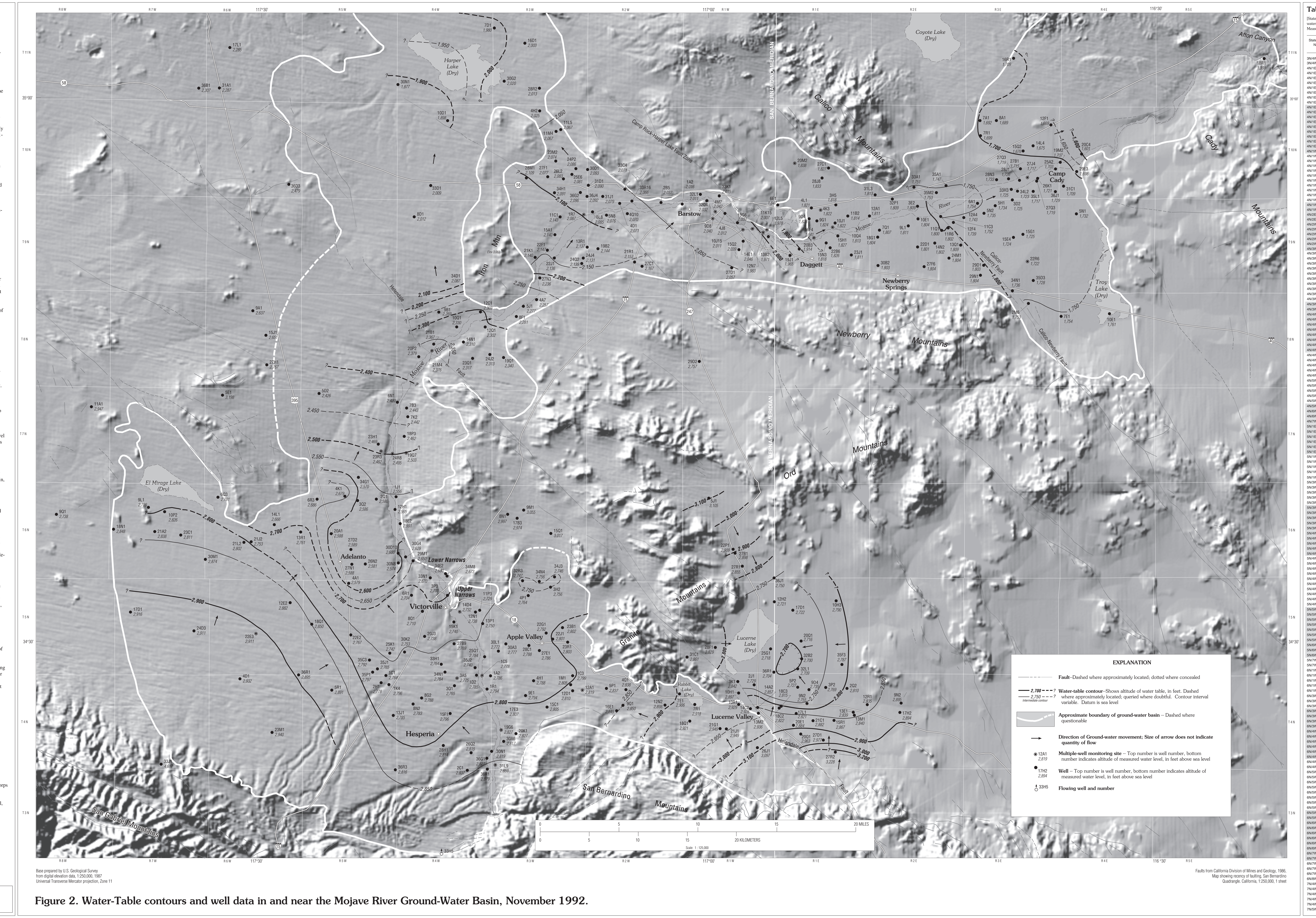


Figure 2. Water-Table contours and well data in and near the Mojave River Ground-Water Basin, November 1992.

Table 1. Water-level measurements, 1990-94, in the Mojave River ground-water basin.

[State well No.: See "Well-Numbering System" section; some numbers subject to change upon verification. USGS identification Number. consists of latitude, longitude, and sequence number. Altitude of water level and altitude of surface in feet above sea level. Water level (depth) in feet below land surface. State well No.: Asterisk (*) indicates multiple-well completion site drilled as part of this study. Measurement method: **S**, steel tape; **R**, reported by other agencies; **V**, calibrated electric tape. --, no data. Site status: **F**, flowing; **R**, recently pumped; **S** nearby pumping; **T**, nearby recent pumping]

State well No.	USGS identification number	Date	Altitude of water level	Water level (depth)	Measurement method	Site status	Altitude of land surface
3N/4W-02C01	342300117160301	05-28-92	2,837	362.63	S		3,200
3N/4W-33H05	341823117174501	12-02-92	--	--		F	3,210
4N/1E-02Q02	342732116504701	06-30-94	2,810	116.07	S		2,926
4N/1E-03P02	342735116521701	06-30-94	2,769	161.30	S		2,930
4N/1E-05P02	342736116540401	05-16-94	2,727	183.40	V		2,910
4N/1E-09D04	342728116531901	10-07-94	2,735	190.28	S		2,925
4N/1E-09N02	342642116532701	04-01-92	2,755	210	R		2,965
4N/1E-12R01	342638116492601	06-30-94	2,835	140.27	S		2,975
4N/1E-13E01	342613116502201	07-22-94	2,839	161.04	S		3,000
4N/1E-13M01	342603116501801	05-16-94	2,840	174.42	S		3,014
4N/1E-15R01	342546116513901	08-29-94	2,867	195.03	S		3,062
4N/1E-17L01	342609116541001	05-18-93	2,821	157.63	S		2,979
4N/1E-18C02	342627116551801	08-03-94	2,822	158.40	S		2,980
4N/1E-18C03	342633116551001	08-03-94	2,815	150	R		2,965
4N/1E-20E01	342530116542101	10-07-94	2,884	136.10	S		3,020
4N/1E-20Q01	342501116535201	10-07-94	2,963	126.73	S		3,090
4N/1E-21C01	342545116530301	07-26-94	2,882	181.37	V		3,063
4N/1E-27D01	342441116522201	10-07-94	2,977	248.15	S		3,225
4N/1E-27R02	342401116513401	07-01-94	3,228	153.33	S		3,381
4N/1W-02J01	342744116565801	10-05-93	2,729	136.8	V		2,866
4N/1W-03K01	342755116580301	07-22-94	2,842	17.53	S		2,860
4N/1W-07E01	342714117015601	07-26-94	2,906	44.5	S		2,950
4N/1W-07R01	342639117005501	07-26-94	2,918	18.29	S		2,936
4N/1W-10H01	342717116580001	10-06-93	2,897	12.69	S		2,910
4N/1W-10R01	342639116580001	11-18-93	2,929	17.41	S		2,946
4N/1W-13M02	342610116564101	11-18-93	2,936	54.30	S		2,990
4N/1W-14A02	342629116564401	08-03-94	2,857	105.34	S		2,962
4N/1W-14C02	342625116571301	10-29-91	2,928	21.93	S		2,950
4N/1W-18Q01	342544117011501	10-06-93	2,921	79.46	S		3,000
4N/1W-21G01	342519116591401	12-02-92	2,949	172.46	S	R	3,121
4N/1W-21J01	342518116584901	03-21-94	2,949	189	R		3,138
4N/1W-26J01	342416116564501	03-21-94	3,097	325.5	R		3,422
4N/2E-09N02	342643116471101	06-30-94	2,895	139.54	S		3,035
4N/2E-17H02	342612116471601	06-30-94	2,894	135.95	S		3,030
4N/2W-04Q01	342728117053001	04-21-94	2,838	241.97	S		3,080
4N/2W-05P01	342732117064801	12-07-93	2,837	238.31	S		3,075
4N/2W-09Q01	342636117054201	03-21-94	2,850	315	R		3,165
4N/2W-12N02	342637117025401	07-26-94	2,898	104.75	S		3,003
4N/2W-16E01	342618117060701	12-07-93	2,849	341.12	V		3,190
4N/3W-01C03	342814117090301	04-21-94	2,799	207.95	R		3,007
4N/3W-01M01	342744117091101	04-21-94	2,805	240.35	V	R	3,045
4N/3W-04H01	342757117113901	02-21-93	2,788	207.48	S		2,995
4N/3W-09E01	342708117121101	11-18-92	2,794	228.10	V		3,023
4N/3W-12A01*	342726117082401	04-19-94	2,819	303.22	S		3,122
4N/3W-12D01	342724117090301	04-19-94	2,810	280.16	V		3,090
4N/3W-15C01	342630117104501	11-15-93	2,805	271.21	V		3,076
4N/3W-17E03	342613117132601	04-21-94	2,807	58.34	S		2,865
4N/3W-19G06*	342517117134301	09-24-93	2,827	54.22	V		2,881
4N/3W-20K01	342502117124901	04-20-94	2,827	143.49	V		2,970
4N/3W-30A06	342436117133801	11-17-92	2,817	77.00	S		2,894
4N/3W-30N01	342403117142601	11-17-92	2,819	121.36	S		2,940
4N/3W-31L09*	342318117141104	12-30-92	2,859	62.74	V		2,922
4N/4W-01A02	342813117143101	11-17-92	2,786	49.62	S		2,836
4N/4W-01C05*	342814117150504	11-19-92	2,778	39.25	V		2,818
4N/4W-01D02	342815117152701	11-18-92	2,785	41.10	S		2,827
4N/4W-01R01	342729117144501	11-19-92	2,794	50.52	S		2,845
4N/4W-03A05*	342805117164504	03-09-94	2,775	207.23	V		2,983
4N/4W-03Q01	342740117165501	06-18-91	2,765	256.18	V		3,021
4N/4W-08G02	342659117190602	12-01-93	2,788	376	R		3,164
4N/4W-08N02	342639117194001	12-01-93	2,783	435	R		3,218
4N/4W-15F01	342608117171201	11-15-92	2,796	305.52	V		3,102
4N/4W-26Q02	342358117154801	12-01-93	2,815	295	R		3,110
4N/4W-28H01	342422117173901	12-01-93	2,814	425	R		3,239
4N/4W-36G01	342340117144501	11-15-92	2,827	102.64	V		2,930
4N/4W-36R01	342304117144301	11-17-92	2,879	44.81	V	S	2,924
4N/5W-01C01	342813117212901	11-11-92	2,764	446	R		3,210
4N/5W-01K04	342743117211701	05-27-92	2,796	454.47	V		3,250
4N/5W-02H01	342749117214801	11-09-92	2,778	487	R		3,265
4N/5W-05R01	342724117250501	06-08-90	2,891	513.01	S		3,404
4N/5W-13J01	342601117205901	12-01-93	2,785	580	R		3,365
4N/5W-36R03	342301117205001	05-29-92	2,816	741.93	V		3,558
4N/6W-04D01	342800117311201	04-06-93	2,932	648.5	R		3,580
4N/6W-23M01	342503117290301	03-08-94	2,940	980.18	V		3,920
4N/7W-33J01	342316117362501	04-06-93	4,617	253.4	R		4,870
5N/1E-10H03	343222116513001	07-21-94	2,790	239.65	S		3,030
5N/1E-17D01	343153116542301	12-17-92	2,722	158.05	S		2,880
5N/1E-20Q01	343009116535001	07-21-94	2,716	147.3	S		2,863
5N/1E-32B02	342910116534801	07-22-94	2,700	169.84	S		2,870
5N/1E-32L01	342837116540401	12-02-92	2,709	160.20	S		2,870
5N/1E-35F03	342851116510701	06-30-94	2,787	154.85	S		2,942
5N/1W-12H02	343219116553701	07-21-94	2,721	151.16	S		2,872
5N/1W-25G01	342943116555201	07-22-94	2,718	132.08	S		2,850
5N/1W-28F01	342948116593301	07-22-94	2,829	35.77	S		2,865
5N/1W-31C01	342916117012601	07-26-94	2,861	218.70	S		3,080
5N/1W-36R01	342826116553901	07-22-94	2,704	156.98	S		2,861
5N/3W-03H02	343307117103201	11-17-93	2,756	163.78	S		2,920
5N/3W-04P01	343239117120101	05-18-94	2,764	145.69	S		2,910
5N/3W-22G01	343035117104901	11-18-92	2,792	142.69	V		2,935
5N/3W-22J01	343015117102301	11-17-93	2,801	133.18	S		2,934
5N/3W-23B01	343053117094401	04-19-93	2,802	113.77	S		2,916
5N/3W-23R01	343005117092301	01-05-93	2,803	126.56	V		2,930
5N/3W-27E01	342937117111601	02-21-93	2,786	163.60	S		2,950
5N/3W-28C01	342954117115801	02-21-93	2,788	169.53	S		2,958
5N/3W-30A03	342959117133003	11-18-92	2,777	182.97	V		2,960
5N/3W-30L01	342935117140001	11-18-92	2,772	86.23	V		2,858
5N/4W-03P03	343239117172401	11-18-92	2,700	9.98	S		2,710
5N/4W-06R01	343239117194801	08-01-93	2,704	155.7	R		2,860
5N/4W-08Q01	343146117190401	01-05-94	2,710	183.90	S		2,894
5N/4W-11P03	343150117151502	11-23-92	2,729	58.94	S		2,788
5N/4W-12N01	343144117153201	02-21-93	2,738	102.35	S		2,840
5N/4W-13P01	343106117150301	02-21-93	2,750	79.91	S		2,830
5N/4W-14D04*	343145117163504	11-19-92	2,732	18.37	V		2,750
5N/4W-15K01	343111117165801	11-18-92	2,740	4.73	S		2,745
5N/4W-20J03	343023117185501	08-01-93	2,738	192.1	R		2,930
5N/4W-25Q01	342916117145501	11-18-92	2,784	15.71	S		2,800
5N/4W-27B09	342959117165701	03-25-93	2,769	50.57	S		2,820
5N/4W-30K02	342931117201501	05-27-92	2,753	304.84	S		3,058
5N/4W-33H01	342851117174801	08-01-93	2,764	230.8	R		2,995
5N/4W-34N01	342825117173301	08-01-93	2,764	236	R		3,000
5N/4W-35J02	342840117153301	11-19-92	2,740	74.73	S	S	2,815
5N/5W-04A01	343318117235901	04-11-94	2,579	370.20	V		2,950
5N/5W-18Q01	343102117262601	03-18-94	2,850	279.23	V		3,130
5N/5W-22E02	343027117235001	09-09-91	2,767	354.99	S		3,122
5N/5W-25K01	342927117211401	08-01-93	2,742	362.8	R		3,105
5N/5W-35C03	342904117223501	11-09-92	2,792	413	R		3,205
5N/5W-35J01	342835117220301	11-09-92	2,765	445	R		3,210
5N/5W-35P01	342824117222201	11-09-92	2,797	438	R		3,235
5N/6W-12E02	343213117275301	11-15-90	2,882	178.00	S		3,060
5N/6W-22E03*	343030117300903	06-08-94	2,911	349.29	V		3,260
5N/6W-36R01	342814117271801	11-09-92	2,895	527	R		3,422
5N/7W-17D01	343139117383101	11-13-92	2,916	308.56	S		3,225
5N/7W-24D03	343038117341701	10-30-91	2,911	435.74	S		3,347
6N/1W-05J01	343802116595901	07-21-94	3,105	115.35	S		3,220
6N/1W-22P01	343513116582201	07-21-94	2,909	150.46	S		3,059
6N/1W-27B01	343500116581401	07-21-94	2,898	141.56	S		3,040
6N/1W-27R01	343417116574501	07-21-94	2,855	182.72	S		3,038
6N/1W-36J01	343338116553801	07-21-94	2,750	197.53	S		2,948
6N/3W-08N01	343708117132401	01-05-93	2,997	74.62	S		3,072
6N/3W-09M01	343722117122001	04-11-94	3,055	22.74	V		3,078
6N/3W-15Q01	343605117103101	10-05-93	3,017	114.97	S		3,132
6N/3W-17B03	343655117124601	04-11-94	2,974	67.94	V		3,042
6N/3W-32R03	343328117122401	01-05-93	2,747	175.10	S		2,922
6N/3W-34J03	343341117101601	05-29-92	2,746	229.28	S	R	2,975
6N/3W-34N04	343326117111701	04-11-94	2,756	164.30	V		2,920
6N/4W-18E02	343636117203401	11-19-92	2,591	9.45	S		2,600
6N/4W-29M01	343433117194201	11-19-92	2,650	10.20	S		2,660
6N/4W-30D10	343458117204201	11-25-92	2,600	91.20	V	R	2,691
6N/4W-30G04	343446117201201	08-05-93	2,629	20.73	S		2,650
6N/4W-30N08	343426117204101	11-17-92	2,574	115.78	V		2,690
6N/4W-33N01	343337117183101	11-18-92	2,670	10.12	S		2,680
6N/4W-34E02	343351117173202	02-21-93	2,680	55.80	S	R	2,736
6N/4W-34M08	343343117172601	11-18-92	2,673	57.19	S		2,730
6N/5W-01J01	343805117205101	11-16-92	2,556	14.08	S		2,570
6N/5W-02Q01	343757117221001	11-19-92	2,580	220.23	S	R	2,800
6N/5W-03Q02	343752117232501	12-08-92	2,586	206.33	V		2,792
6N/5W-04K01	343806117241601	03-09-94	2,679	91.49	S		2,770
6N/5W-06R03	343756117260701	03-10-94	2,686	77.96	S		2,764
6N/5W-12H01	343723117205501	11-25-92	2,565	14.66	S	R	2,580
6N/5W-20A01	343602117251001	03-10-94	2,588	234.05	S		2,822
6N/5W-26N02	343422117225301	04-12-94	2,581	309.27	V		2,890
6N/5W-27D02	343510117234901	04-11-94	2,589	279.38	V		2,868
6N/5W-27N01	343421117234701	04-12-94	2,588	307.18	V		2,895
6N/6W-06Q03	343801117324401	05-21-93	2,781	114.00	S		2,895
6N/6W-13R01	343607117271201	06-22-93	2,761	55.99	S		2,817
6N/6W-14L01	343631117285801	11-15-92	2,666	142.98	M	T	2,809
6N/6W-21J02	343534117303001	05-27-91	2,753	133.03	S		2,886
6N/6W-21L02	343532117305902	04-01-94	2,802	92.65	V	T	2,895
6N/6W-30M01	343435117333301	11-15-92	2,874	118.34	V		2,992
6N/7W-09L01	343726117372201	04-28-93	2,786	76.43	S		2,862
6N/7W-10P02	343712117361701	10-30-91	2,826	37.49	S		2,864
6N/7W-18N01	343613117394101	04-28-93	2,848	66.65	V		2,915
6N/7W-21A02	343606117365601	11-01-90	2,838	70.64	S		2,909
6N/7W-23C01	343555117351201	11-15-90	2,811	101.83	S		2,913
6N/8W-09Q01	343701117433001	03-20-91	2,738	53.08	S		2,791
7N/4W-06N01	344318117204701	11-19-92	2,420	69.61	S		2,490
7N/4W-07B03	344259117201001	11-17-92	2,443	26.63	S		2,470
7N/4W-07K02	344230117200501	11-25-92	2,442	48.48	S		2,490
7N/4W-18P03	344125117201901	11-17-92	2,462	53.15	S		2,515
7N/4W-19Q07*	344034117200201	11-16-92	2,503	87.03	V		2,590
7N/5W-05D02	344346117260101	11-20-92	2,426	293.62	V		2,720
7N/5W-23H01	344059117220301	11-19-92	2,469	246.39	S		2,715
7N/5W-23R03*	344036117215203	11-19-92	2,482	242.60	V		2,725
7N/5W-24R08*	344028117210604	11-16-92	2,495	9.98	V		2,505
7N/5W-34G01	343909117232201	03-09-94	2,570	176.15	S		2,746
7N/6W-05E01	344339117322801	05-12-93	3,198	297.63	S		3,496
7N/8W-11A01	344258117411301	05-17-93	2,947	35.07	S		2,982
8N/1W-29D02	344535117003701	11-16-93	2,757	92.57	S		2,850
8N/3E-02M06	344845116383701	04-20-93	1,753	74.71	S	R	1,828
8N/3W-04A07	344859117113001	11-19-92	2,257	17.55	S		2,275
8N/3W-05J01	344841117125301	11-24-92	2,277	12.74	S		2,290
8N/3W-08F01	344803117125101	11-18-92	2,281	33.76	S		2,315
8N/3W-19Q01	344547117134201	11-14-92	2,340	173.52	V		2,514
8N/4E-07E01	344802116362601	09-25-91	1,754	48.90	S		1,803
8N/4E-10E01	344810116331201	04-20-93	1,761	21.33	S		1,782
8N/4W-09B01	344817117180201	11-15-90	2,269	195.07	S		2,464
8N/4W-10Q01	344728117165001	11-17-92	2,330	24.84	S	S	2,355
8N/4W-12C01	344818117151501	11-19-92	2,303	46.70	S		2,350
8N/4W-12Q01	344728117145601	11-17-92	2,302	26.38	S		2,329
8N/4W-14N01	344638117162301	06-24-91	2,310	150.35	S		2,460
8N/4W-20P02	344549117192201	11-17-92	2,379	25.25	S		2,404
8N/4W-21B01	344631117182201	11-18-92	2,367	17.75	S		2,385
8N/4W-21M04*	344609117182904	09-24-93	2,376	9.49	V		2,385
8N/4W-23Q01	344544117154601	11-15-90	2,317	172.50	S		2,489
8N/4W-24J02	344557117143701	11-14-92	2,313	164.99	S	R	2,478
8N/6W-09A01	344819117302801	11-21-92	2,637	127.69	V		2,765
8N/6W-15J01	344658117293501	11-21-92	2,651	158.44	V		2,809
8N/6W-27H01	344520117293101	10-26-92	2,767	165.01	R		2,932
9N/1E-03H05	345413116512902	11-20-91	1,818	131.82	S		1,950
9N/1E-04K03*	345356116523003	09-21-93	1,822	142.62	S		1,965
9N/1E-04L01	345403116530701	05-18-93	1,821	141.81	V		1,963
9N/1E-06E01	345413116552201	04-22-93	1,847	251.85	S		2,099
9N/1E-09D04	345327116531601	11-17-92	1,828	161.82	S		1,990
9N/1E-09G01	345320116524501	05-20-93	1,824	149.45	V		1,974
9N/1E-10J01	345313116513201	05-18-93	1,822	125.96	V		1,948
9N/1E-10Q04*	345259116514203	09-21-93	1,813	134.37	V		1,948
9N/1E-11B02	345336116504101	11-17-92	1,814	140.95	S		1,955
9N/1E-12A01	345336116491401	11-20-92	1,811	103.99	S		1,915
9N/1E-15H01	345230116512101	11-16-92	1,827	132.54	S		1,960
9N/1E-15N03	345207116520801	11-17-92	1,818	151.82	S		1,970
9N/1E-16F04*	345224116525704	09-21-93	1,841	108.85	S		1,950
9N/1E-19J01	345126116543301	04-23-93	1,965	178.67	S		2,144
9N/1E-20B03	345147116535601	11-17-92	1,914	126.40	S		2,040
9N/1E-22B06	345151116515201	11-17-92	1,826	145.18	S	R	1,971
9N/1E-23J01	345127116502701	11-17-92	1,811	169.02	S		1,980
9N/1W-04J08	345345116585401	11-20-92	2,012	37.92	S		2,050
9N/1W-04M07*	345351116593304	01-28-93	2,042	28.17	V		2,070
9N/1W-09D08*	345328116594304	02-11-93	2,040	54.17	V		2,094
9N/1W-10G06	345314116580401	11-24-92	2,039	19.06	S		2,058
9N/1W-10J15*	345251116574204	11-16-92	2,011	21.77	V		2,033
9N/1W-11K15*	345254116570404	11-16-92	2,007	14.57	V		2,022
9N/1W-12L05*	345251116560604	11-16-92	1,978	24.27	V		2,002
9N/1W-12N07*	345242116562104	11-16-92	1,983	26.74	V		2,010
9N/1W-13B02	345228116560001	11-24-92	1,971	28.78	S		2,000
9N/1W-14E01	345213116574101	03-25-93	2,046	115.05	V		2,161
9N/1W-15Q02	345145116575801	01-14-92	2,039	210.72	S		2,250
9N/1W-27D01	345045116582701	06-24-93	2,057	422.75	S		2,480
9N/2E-03E02	345408116460101	11-16-92	1,809	66.48	S		1,875
9N/2E-07Q01	345249116483401	11-23-92	1,807	124.46	S		1,931
9N/2E-09L01	345303116463801	11-17-92	1,811	93.59	S		1,905
9N/2E-10E01	345326116455901	11-20-92	1,804	85.69	S		1,890
9N/2E-11C03	345334116442801	11-23-92	1,752	126.26	S	R	1,878
9N/2E-11Q01	345248116442401	11-16-92	1,800	75.50	S		1,875
9N/2E-11R06	345256116435801	12-10-92	1,802	68.58	V	T	1,871
9N/2E-12A04	345330116425501	11-16-92	1,743	101.74	S		1,845
9N/2E-12F04	345314116433701	12-10-92	1,739	115.05	S		1,855
9N/2E-13Q01	345203116430801	12-10-92	1,809	58.48	V		1,867
9N/2E-14N02	345206116445201	11-24-92	1,802	83.98	S		1,886
9N/2E-18G01	345226116484101	11-17-92	1,804	128.96	S		1,933
9N/2E-22D01	345153116460101	05-18-93	1,801	101.15	S		1,902
9N/2E-24M01	345116116435501	04-21-93	1,804	74.33	S		1,878
9N/2E-27F06	345048116453501	04-21-93	1,804	96.30	S		1,900
9N/2E-30B02	345052116484001	04-21-93	1,803	161.99	S		1,965
9N/2W-01A02	345416117014601	11-17-92	2,016	89.27	S		2,105
9N/2W-02B05	345421117031101	11-19-92	2,037	93.47	S		2,130
9N/2W-04D01	345418117055701	11-17-92	2,071	99.33	S		2,170
9N/2W-04Q10	345344117052601	11-18-92	2,070	95.40	S		2,165
9N/2W-05N08	345339117065001	11-18-92	2,076	107.90	S		2,184
9N/2W-06L08	345350117074601	11-18-92	2,085	105.26	S		2,190
9N/2W-19B02	345148117072401	11-21-92	2,144	115.97	V	R	2,260
9N/2W-21R01	345104117045701	05-17-94	2,153	236.88	V		2,390
9N/2W-27C01	345050117042701	11-21-92	2,167	278.48	V	R	2,445
9N/3E-03D02	345428116394001	11-16-92	1,725	92.62	S		1,818
9N/3E-05H01	345409116404901	11-16-92	1,734	91.27	S	R	1,825
9N/3E-05N02	345344116413401	11-16-92	1,735	105.42	S		1,840
9N/3E-06A01	345417116420001	11-13-92	1,754	85.89	S		1,840
9N/3E-15E04	345224116393601	12-09-92	1,724	103.24	V		1,828
9N/3E-15G01	345234116385801	06-10-91	1,725	97.39	S		1,822
9N/3E-22R06*	345104116384003	09-21-93	1,722	103.49	V		1,825
9N/3E-29D01	345052116413601	12-10-92	1,803	52.03	V		1,855
9N/3E-29N01	345019116414901	12-09-92	1,804	49.87	V		1,854
9N/3E-34N01	344927116394101	11-24-92	1,736	83.68	S	R	1,820
9N/3E-35D03	345001116381701	01-15-93	1,728	94.21	V		1,822
9N/3W-01R07*	345341117082103	11-16-92	2,087	107.65	V		2,195
9N/3W-11C01	345333117095601	01-20-93	2,143	77.18	S		2,220
9N/3W-13R01	345153117080701	11-24-92	2,137	107.82	V		2,245
9N/3W-15A01	345234117101701	11-17-92	2,140	74.85	S		2,215
9N/3W-22F01	345143117104701	11-17-92	2,147	77.57	S		2,225
9N/3W-21K01	345119117113601	11-23-92	2,140	106.30	S	R	2,246
9N/3W-22J01	345117117101901	11-17-92	2,136	93.67	V		2,230
9N/3W-24J04	345117117082301	11-18-92	2,131	178.60	S		2,310
9N/3W-24Q02	345059117082901	11-17-92	2,139	200.87	V		2,340
9N/3W-27N03	345011117111701	11-17-92	2,236	29.26	S		2,265
9N/4E-05N01	345341116352301	12-10-92	1,732	57.89	S		1,790
9N/4W-08D01	345332117194201	11-21-92	2,012	343.21	V		2,355
9N/4W-34D01	344959117173101	04-21-93	2,087	396.06	S		2,483
10N/1E-20M02*	345631116541402	09-23-93	1,838	251.25	V		2,090
10N/1E-27C01	345615116515801	06-21-93	1,827	257.7	S		2,085
10N/1E-28J08	345542116522401	04-22-93	1,833	138.92	S		1,972
10N/1W-32L01	345448117003301	11-17-92	2,011	73.91	S		2,085
10N/1W-32Q04	345427117000701	11-17-92	2,032	48.40	S		2,080
10N/1W-33K01	345443116591701	11-17-92	2,015	74.59	S		2,090
10N/2E-31L03	345446116485101	06-02-92	1,813	121.91	S		1,935
10N/2E-32P01	345432116474201	11-17-92	1,809	96.39	S		1,905
10N/2E-33A01	345511116461501	11-17-92	1,751	168.72	S		1,920
10N/2E-35A01	345516116440601	11-17-92	1,747	127.85	S		1,875
10N/2E-35M02	345453116444501	11-18-91	1,753	121.70	S		1,875
10N/2W-30D01	345610117080601	01-19-93	2,093	86.94	S		2,180
10N/2W-31D01	345518117080301	01-19-93	2,090	85.28	S		2,175
10N/2W-31J01	345441117070501	11-18-92	2,079	95.98	S		2,175
10N/2W-33C04	345505117053604	01-20-93	2,071	94.48	S	T	2,165
10N/2W-33R16	345426117050801	11-23-92	2,066	92.77	S	R	2,159
10N/3E-07A01	345851116414901	11-18-92	1,692	109.65	V		1,802
10N/3E-07R01	345801116414701	01-13-93	1,699	120.15	V		1,819
10N/3E-08A01	345851116404301	11-18-92	1,690	112.59	S	R	1,802
10N/3E-12F01	345836116370401	11-18-92	1,669	107.59	S		1,777
10N/3E-14L04	345727116381601	11-13-92	1,675	115.04	S		1,790
10N/3E-15Q02	345710116385601	11-13-92	1,676	124.42	S		1,800
10N/3E-25A02	345610116364601	11-13-92	1,703	12.44	S		1,715
10N/3E-26K01	345539116375801	11-12-92	1,721	30.37	S		1,751
10N/3E-26Q01	345530116380201	11-12-92	1,719	50.97	S		1,770
10N/3E-27B01	345611116390701	11-12-92	1,715	84.55	S		1,800
10N/3E-27J04*	345542116383904	11-16-92	1,717	32.37	S		1,750
10N/3E-27Q03	345533116391101	11-13-92	1,719	40.70	S		1,760
10N/3E-28J01	345538116395501	11-17-92	1,726	83.82	S		1,810
10N/3E-28N03	345535116404301	11-17-92	1,733	86.84	S		1,820
10N/3E-33H03	345503116394401	11-16-92	1,725	49.78	S		1,775
10N/3E-34L02	345457116391901	11-13-92	1,723	73.70	S		1,797
10N/3E-35L01	345456116381601	11-12-92	1,717	82.74	S		1,800
10N/3E-36J01	345455116364701	06-10-91	1,729	71.33	S		1,800
10N/3W-04H02	345924117111901	11-18-92	2,025	74.67	S		2,100
10N/3W-11L05	345822117095401	11-18-92	2,067	63.09	S	R	2,130
10N/3W-11M04	345816117101301	11-18-92	2,067	65.53	S		2,133
10N/3W-23M02	345638117101401	01-19-93	2,074	85.34	S		2,159
10N/3W-24P02	345613117085301	12-10-92	2,086	78.56	S		2,165
10N/3W-25E06	345554117090901	03-24-93	2,081	86.77	S	R	2,168
10N/3W-26L02	345539117094301	12-10-92	2,083	90.05	S		2,173
10N/3W-27F01	345546117104601	11-14-90	2,077	92.46	S		2,169
10N/3W-28M01	345542117121201	11-01-90	2,109	67.37	S		2,176
10N/3W-34H01	345453117101901	01-20-93	2,091	112.15	S		2,203
10N/3W-36G02	345454117083501	03-18-93	2,096	86.09	S		2,182
10N/3W-36J04	345441117080801	03-18-93	2,092	93.29	S	R	2,185
10N/4E-19M02	345632116362701	11-12-92	1,707	3.34	S		1,710
10N/4E-20C04	345659116350101	11-12-92	1,601	128.56	V		1,730
10N/4E-29E03	345601116352101	11-12-92	1,698	42.40	S		1,740
10N/4E-31C01	345513116361401	11-12-92	1,709	60.80	V		1,770
10N/4W-10D01	345851117172901	11-19-92	1,898	236.53	S		2,135
10N/4W-33D01	345516117183601	06-24-93	2,009	269.55	S		2,279
10N/6W-36D03	345518117280601	11-17-92	2,479	241.00	S		2,720
11N/3E-16R01	350217116393301	11-19-92	1,709	73.41	V		1,782
11N/3W-07D01	350358117142201	11-22-92	1,980	91.13	V		2,071
11N/3W-16D01	350308117121901	11-22-92	2,003	73.72	V		2,077
11N/3W-28R02	350039117112101	11-23-92	2,013	59.42	S	R	2,073
11N/3W-30G02	350102117134201	11-22-92	2,020	15.23	V		2,035
11N/4W-30N01	350050117204901	11-21-92	1,877	223.07	V		2,100
11N/6E-18R01	350212116224501	11-12-92	1,391	18.54	S		1,410
11N/6W-17L01	350250117320601	11-15-92	2,285	271.05	S		2,556
11N/6W-31A01	350036117324701	11-19-92	2,287	174.81	S		2,462
11N/7W-36B01	350035117341001	11-19-92	2,307	169.66	S		2,477

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